

Report for Congress

Received through the CRS Web

Homeland Security: Protecting Airliners from Terrorist Missiles

Updated March 25, 2003

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20050214 033

Homeland Security: Protecting Airliners from Terrorist Missiles

Summary

Recent events have focused attention on the threat that terrorists with shoulder fired surface-to-air missiles (SAMs) pose to commercial airliners. Most believe that no single solution exists to effectively mitigate this threat. Instead, a menu of options may be considered, including installing infrared (IR) countermeasures on aircraft; modifying flight operations and air traffic control procedures; improving airport and regional security; and strengthening missile non-proliferation efforts. Equipping aircraft with missile countermeasure systems can protect the aircraft even when operating in areas where ground-based security measures are unavailable or infeasible to implement. However, this option has a relatively high cost, between \$1 million and \$3 million per aircraft, and the time needed for implementation does allow for immediate response to the existing terrorist threat. Procedural improvements such as specific flight crew training, altering air traffic procedures to minimize exposure to the threat, and improved security near airports may be less costly than countermeasures and could more immediately help deter domestic terrorist attacks. However, these techniques by themselves cannot completely mitigate the risk of domestic attacks and would not protect U.S. airliners flying to and from foreign airports. On February 5, 2003, Rep. Steve Israel and Sen. Barbara Boxer introduced legislation (H.R. 580, S. 311) calling for the installation of missile defense systems in all turbojet aircraft used in scheduled air carrier service. On March 13, 2003, during a mark-up session of the Senate Committee on Commerce, Science, and Transportation, Sen. Boxer offered an amendment to S. 165 that would direct the Secretary of Homeland Security to conduct a 90-day study of the threat and report to Congress on recommendations for protecting airliners against shoulder fired missiles. The committee adopted Sen. Boxer's amendment and ordered S. 165 reported favorably with amendments. On March 20, 2003, the House Aviation Subcommittee held a closed hearing on the matter, after which Subcommittee Chairman John Mica indicated that options for protecting airliners against shoulder launched missiles would be further explored and funding for these initiatives would be pursued. This report will be updated as needed.

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Homeland Security: Protecting Airliners from Terrorist Missiles

Introduction

The effectiveness of shoulder fired surface-to-air missiles (SAMs) against military aircraft is well established.¹ Recent events, however, have drawn increased attention to the threat that these SAMs may pose to commercial airliners. Two incidents in particular stand out: on November 6, 2002 three men with links to *Al Qaeda* tried to buy *Stinger* SAMs from FBI agents in Hong Kong; on November 28, 2002, terrorists fired two SA-7 SAMs at an Israeli airliner departing Mombasa, Kenya. These incidences are not isolated events. The FBI estimates that there have been at least 29 instances in which civilian planes have been hit by shoulder fired SAMs, causing up to 550 deaths.² RAND provides a different estimate: their analysis shows that as many as 40 civilian airliners were shot down by these weapons between 1975 and 1992; causing up to 760 deaths.³

Examples of shoulder fired SAMs include the U.S. *Stinger* and *Redeye*, and the Russian SA-7, SA-14, SA-16, and SA-18. These weapons are relatively inexpensive, widely proliferated, and easy to conceal and use. Once launched, these missiles are difficult for a targeted aircraft to detect, which means that there is often no warning of an attack. Estimates of the global inventory of man portable SAMs range from 500,000 to 700,000 systems.⁴ Their low price – between \$5,000 and \$30,000 on the black market – may make them accessible to terrorists.⁵ Some estimate that 27 militia groups and terrorist organizations own shoulder fired SAMs.⁶ Also, about 400 *Stingers* provided to Afghan rebels in the 1980s remain at

¹ See CRS Report RS21141. *Military Suppression of Enemy Air Defenses (SEAD): Assessing Future Needs*.

² Thom Shanker. "Ideal Terror Weapons: Portable Deadly, Plentiful Missiles." *New York Times*. November 29, 2002. p.32.

³ Marvin B. Shaffer. *Concerns about Terrorists with Manportable SAMs*. RAND. Santa Monica, CA. October 1993. p.3. Available data indicates that most of these incidents, involving various aircraft including civilian jet airliners, turboprops, and helicopters, occurred in war zones.

⁴ John Mintz. "U.S. Acts to Thwart Missile Threat Against Airliners." *Washington Post*. January 15, 2003. p.1.

⁵ Vivienne Walt. "Portable Missiles Concern Senators." *USAToday*. December 2, 2002. p.1

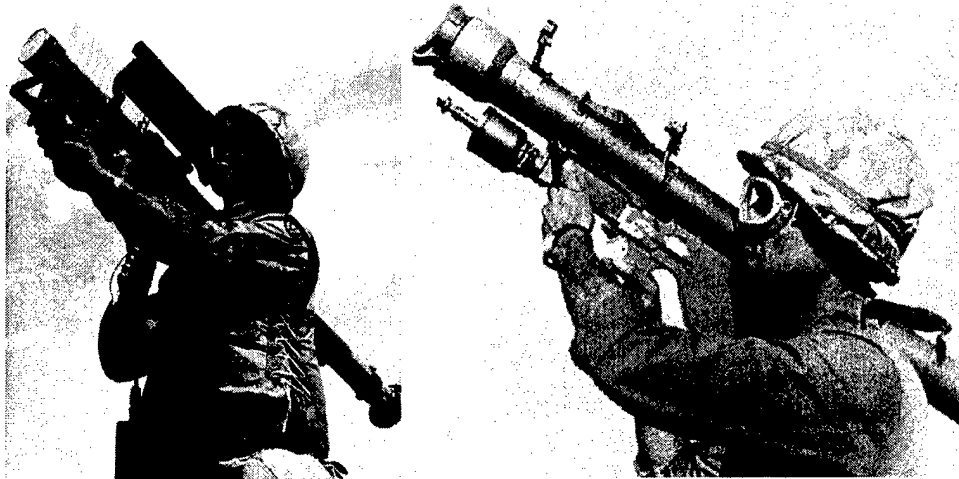
⁶ *Ibid.*

large.⁷ Shoulder fired SAMs are approximately 5 feet long, 3 inches in diameter, and weigh between 10 and 35 lbs. This small size makes them easy to conceal. Shoulder fired SAMs are also relatively easy to use, but do require some training to use them proficiently. They are employed much like a rifle: an individual rests the weapon on his or her shoulder, looks through a sight, and pulls a trigger.

Shoulder fired SAMs are effective up to 15,000 feet in altitude, and approximately 3 miles in range. Thus, while airliners are safe from these SAMs when flying at cruising altitude (30,000 feet), they are vulnerable when taking off and landing. Shoulder fired SAMs are frequently called heat seeking missiles because they employ sensors that search for and home in on the target's infrared (IR) signature, often the engine. A significant feature of IR guidance is that it does not emit detectable energy that can warn targeted aircraft. Radar-guided SAMs, in contrast, are easy to detect once an aircraft is targeted.

The Bush Administration has formed a task force to assess the vulnerability of U.S. airports to SAMs. Many in Congress are concerned about the threat shoulder

Figure 1: Stinger (L) and SA-7 (R) Missiles



fired SAMs could pose to airliners. Specific concerns include protecting civilians and mitigating the potential financial burden for an already besieged industry. Legislation is being proposed, as are hearings on the subject.⁸ On February 5, 2003 Rep. Steve Israel and Sen. Barbara Boxer introduced legislation (H.R. 580, S. 311) directing the Secretary of Transportation to issue regulations requiring airliners to be equipped with missile defense systems.

⁷ David Learmount. "Can Countermeasures Work?" *Flight International*. December 10, 2002.

⁸ Marc Selinger. "Lawmakers push anti-missile systems for commercial aircraft." *Aerospace Daily*. January 21, 2003. and Walt Opcit

Options for Mitigating Missile Threats

Most observers believe that no single solution exists to effectively mitigate the SAM threat to airliners. Instead, a menu of options may be considered, including improvements or modifications to commercial aircraft, changes to pilot training and air traffic control procedures, and improvements to airport and local security.

IR Countermeasures and Aircraft Improvements. Military aircraft employ a variety of countermeasures to mitigate the threat posed by SAMs. With few exceptions, commercial airlines today do not employ these protective systems.⁹ Historical arguments against fielding countermeasures on airliners include the countermeasure's acquisition cost, cost and difficulty of integrating them into the aircraft, life cycle costs, environmental constraints on their use, and the fear that they may promote perceptions that flying is not safe. Estimates of the cost of acquiring and installing IR countermeasures on commercial aircraft range between \$1 million and \$3 million per aircraft.¹⁰ According to FAA forecasts, there will be about 5,104 passenger jet aircraft in service in 2003, of which 3,376 are large narrowbody airplanes, 703 are large widebodies, and 1,025 are regional jets. Additionally, there are expected to be 1,108 all-cargo jets deployed in air carrier operations in 2003.¹¹ Estimates on equipping the air carrier fleet with IR countermeasures vary because of assumptions regarding the type of system, whether they would be installed directly into the aircraft or attached via a pod, and the overall number to be procured. Some IR countermeasures could increase the airline's operating costs by increasing the aircraft's weight and drag and thus the amount of fuel consumed. Another issue for installing IR countermeasures on passenger jets is the logistics of equipping the fleet and the potential indirect costs associated with taking airplanes out of service to accomplish these installations.

For decades, military aircraft have ejected inexpensive flares to foil IR-guided SAMs. When a white-hot flare passes through an IR-guided SAM's field of view, its intense IR energy can confuse the missile and cause it to lose its lock on the targeted aircraft. Although effective against older shoulder fired SAMs, flares often cannot fool newer models, which use more sophisticated sensors. Also, most flares pose a fire hazard to combustibles on the ground, and may be too risky for urban areas. DoD has recently developed new flares and similar decoys that may be more effective against modern IR-guided missiles, and pose less of a fire hazard.

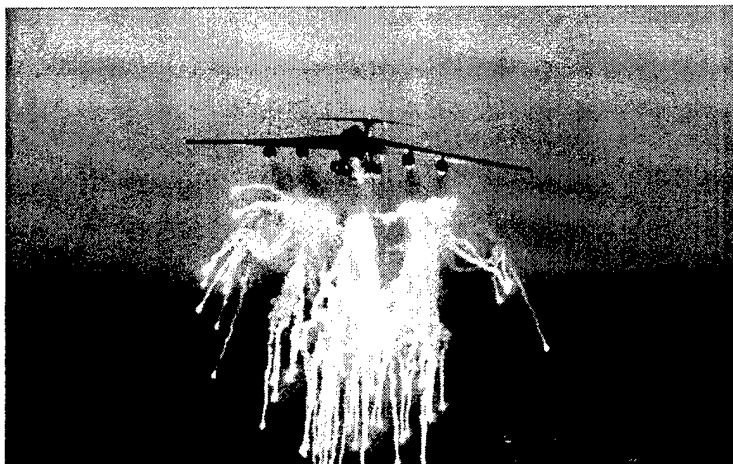
⁹ It has been reported that the Israeli airline El Al has deployed or is in the process of equipping some or all of its 34 aircraft with missile countermeasure systems.

¹⁰ David Learmount. "Can Countermeasures Work?" *Flight International*. December 10, 2002. Robert Wall & David A. Fulghum. "Israel to Protect Airliners; U.S. on the Fence." *Aviation Week & Space Technology*. December 9, 2002. p.26.

¹¹ Federal Aviation Administration. *FAA Aerospace Forecasts Fiscal Years 2002-2013*. Available at: [<http://api.hq.faa.gov/clientfiles/CONTENT.htm>]

Military aircraft also use a variety of transmitters – known as IR countermeasures, or IRCMs to create fields of IR energy designed to confuse shoulder fired SAMs. Unlike flares, IRCMs do not pose a fire hazard to combustibles on the ground. Like flares, however, they are only effective against older IR-guided missiles. Recent advances in lasers have led to the development and

Figure 2: C-141B Starlifter Ejecting Flares on Takeoff



employment of directed IRCMs (DIRCMs), that focus their IR energy directly on the incoming SAM. DIRCMs are able to generate more jamming power than IRCMs, and may offer the most effective defense against modern shoulder fired SAMs. DIRCM weight, size, cost, and reliability, however, may not yet make them attractive for commercial airlines.

Military aircraft use flares and IRCMs preemptively: in anticipation of a SAM launch, a pilot can eject numerous flares, or turn on the IRCM to foil a potential threat. However, environmental considerations may make the use of flares difficult for commercial airlines. DIRCM's can't be used preemptively. They must be aware that a missile has been launched, and use missile approach and warning systems (MAWS) for that function.¹² Because IR-guided SAMs are difficult to detect, MAWS performance is a key factor in the overall effectiveness of the aircraft's protection system. DoD is also developing paint that is designed to reduce an aircraft's IR reflectivity and visual profile. IR camouflage paint would not reduce an engine's heat signature, but it might make it more difficult for terrorists to visually see the aircraft, and thus could avert a SAM launch. The Navy is studying IR camouflage paint on the V-22 *Osprey*.¹³ The cost and maintainability of this paint is still being studied, but the paint might actually be lighter than conventional aircraft paint. Today, IR paint appears to offer few complications for airline application compared to other potential countermeasures.

¹² MAWS are also employed on aircraft that use flares and IRCMs.

¹³ Stephen Trimble. "Glitches Pose Little Threat to V-22 Flight Trial Results, Navy Says." *Aerospace Daily*. January 29, 2003.

In addition to equipping airliners with missile countermeasures, strengthening the airframe to better withstand missile strikes has been suggested. To date, the FAA's Commercial Aircraft Hardening Program has primarily focused on studying how hardened aircraft can better withstand internal bomb blasts.¹⁴ The survivability of passenger jets following missile strikes is largely unknown. It is expected that developing hardened aircraft structures will be a challenging problem given that IR guidance systems seek hot engine exhaust and will likely detonate at or near an aircraft engine. Since most jet airliners have wing-mounted engines, hardening of surrounding aircraft structure will likely be infeasible, particularly with regard to modifying existing aircraft. This option would likely require extensive research before its feasibility and effectiveness could be adequately assessed. Initial indications suggest that aircraft hardening and structural redesign, if feasible, will likely be very costly and could take many years to implement.

Improved Pilot Training and Air Traffic Procedures. Airline pilots already receive substantial simulator training on handling loss of power to one engine during critical phases of flight such as takeoffs and landings. This training should already prepare flight crews to handle a loss of engine power resulting from a missile strike. Therefore, additional training for handling missile attacks may be of limited benefit. On the other hand, specific simulator exercises using missile attack scenarios may be beneficial by preparing pilots to fly and land a damaged aircraft. Modern airliners are built with redundancy in avionics and flight control systems, and consequently, a missile strike that does not cause a catastrophic structural failure would likely be survivable if the flight crew is properly trained to handle such a scenario.

Another potential mitigation technique is training flight crews in evasive maneuvers if fired upon by a shoulder fired SAM. However, this approach would not likely be effective and presents significant risks. Without a missile detection and warning system, it is unlikely that a flight crew would have any indication of a missile launch. Also, large transport category airplanes are generally not maneuverable enough to evade a shoulder fired SAM. There is also concern that defensive maneuvering of large transport category airplanes could result in a loss of control or structural failure.¹⁵ Consequently, most observers concur that evasive maneuvering is not a viable option for mitigating the risk of missile attacks. However, properly trained crews may be able to use other special procedures to evade missile attacks. Examples of procedures that may be considered to reduce the airplanes heat signature and vulnerability to missile strikes include: minimizing the use of auxiliary power units and other heat sources when operationally feasible;

¹⁴ Howard J. Fleisher. "Commerical Aircraft Vulnerability Assessment and Threat Mitigation Techniques." *Aircraft Survivability*, Fall 2002, 24-25. Available at: [<http://www.bahdayton.com/surviac/asnews.htm>]

¹⁵ See Dave Carbaugh, John Cashman, Mike Carriker, Doug Forsythe, Tom Melody, Larry Rockliff, & William Wainwright, "Aerodynamic Principles of Large-Airplane Upsets." FAST Special: Airbus Technical Digest, June 1998. Available at [<http://www.airbus.com/customer/fastspecial.asp>] (Also published in Boeing Aero No. 3).

minimizing engine power settings; and, if a missile launch is detected, reducing engine power settings to minimum levels required to sustain flight at a safe altitude. The effectiveness and safety risks associated with techniques such as these will need to be carefully assessed before procedural measures are implemented.

Another mitigation technique may be to alter air traffic procedures to minimize the amount of time airliners are vulnerable to missile launches and make flight patterns less predictable. Current arrival procedures rely on gradual descents along well defined and publicly known approach courses that place airplanes within range of shoulder fired SAMs as far away as 50 miles from the airport.¹⁶ Similarly, departing aircraft with heavy fuel loads operating at high engine power, often along predefined departure routes may be particularly vulnerable and can be targeted up to 30 miles away from the airport before they climb above the effective range of shoulder fired SAMs.¹⁷

Military aircraft often use spiral descents from altitude above the airfield when operating in hostile areas. Using spiral descents may be an option for mitigating the threat of terrorist attacks to airliners approaching domestic airports from shoulder fired SAMs. Doing so can limit approach and descent patterns to a smaller perimeter around the airfield where security patrols can more effectively deter terrorist attacks. While spiral approaches may be implemented on a limited basis, wide scale use of spiral patterns would likely require extensive restructuring of airspace and air traffic procedures. This technique may present safety concerns by greatly increasing air traffic controller workload and requiring pilots to make potentially difficult turning maneuvers at low altitude. The use of spiral patterns could also reduce passenger comfort and confidence in flight safety. Also, this technique would not mitigate the risk to departing aircraft, which are generally considered to be the most vulnerable to missile attacks.

Another option that may be considered is to vary approach and departure patterns. Regularly varying approach and departure patterns in non-predictable ways, may make it more difficult for terrorists to set up a shoulder fired SAM under a known flight corridor and may increase the probability that they will be detected trying to locate a usable launch site by ground surveillance, local law enforcement, or civilians reporting suspicious activities. One challenge to implementing this technique is that aviation radio frequencies are not protected, and terrorists might gather intelligence regarding changing flight patterns. Nonetheless, this approach could be a deterrent by making overflights of particular locations less predictable. Limitations to this approach include disruption of normal air traffic flow which may result in delays, increased air traffic controller workload, and possible interference with noise mitigation procedures. Varying air traffic patterns may be a viable mitigation technique, particularly at airports with low to moderate traffic and for approach and departure patterns that overfly sparsely populated areas. Also, maximizing the use of over water approach and departure procedures, when available, coupled with measures to limit or restrict access to and increase patrols

¹⁶ Marvin B. Shaffer. *OpCit.*

¹⁷ Robert Wall & David A. Fulghum. *OpCit.*

of waters under these flight paths has also been suggested as a mitigation alternative.¹⁸

Other suggested changes to air traffic procedures include the increased use of nighttime flights and minimal use of aircraft lighting. However, this approach is likely to be opposed by the airlines and passengers since there is little demand for night flights in many domestic markets. Furthermore, minimizing the use of aircraft lighting raises safety concerns for aircraft collision avoidance. While the airspace system includes good radar coverage in the vicinity of airports and airliners are required to have collision avoidance systems, the last line of protection against midair collisions is the flight crew's ability to see and avoid other aircraft. Therefore, increased use of night flights and minimizing aircraft lighting is not thought to be a particularly viable mitigation option.

Improvements to Airport and Local Security. One of the most expedient measures that can be taken to mitigate the risk from shoulder fired SAMs to airliners is to heighten security, surveillance, and patrols in the vicinity of airports served by air carriers. The difficulty with implementing these security measures is that the approach and departure corridors where aircraft operate within range of shoulder fired SAMs extend for several miles beyond airport perimeters. Therefore, while heightening security in the immediate vicinity of an airport may reduce the threat from shoulder fired SAMs, these measures cannot effectively mitigate the threat during the entire portion of flight while airliners are vulnerable to attack. Nonetheless, using threat and vulnerability assessments, airport and airspace managers can work with security forces to determine those locations beyond the airport perimeter that have high threat potential and where aircraft are most vulnerable to attack. Using this information, security can concentrate patrols and surveillance in these high risk areas. Airport security managers will likely need to work closely with local law enforcement to coordinate efforts for patrolling these high risk areas. Public education and neighborhood watch programs in high risk areas may also be effective means to mitigate the threat. Aerial patrols using sensor technology, such as Forward Looking Infrared (FLIR), may also be an effective tool for detecting terrorists lurking underneath flight paths. However, use of aerial patrols may significantly impact normal flight schedules and operations, particularly at the nation's larger airports.

In addition to increased security, some have suggested using ground based countermeasures in high risk locations. Randomly dispensing flares in the vicinity of airports has been suggested, noting that the Israeli airline El Al occasionally used this technique during periods of heightened tension in the 1980s. However, ground-based flares pose a risk of fires on the ground and therefore would not be suitable at many airports in the United States, particularly those surrounded by populated or wooded areas. Furthermore, dispensing flares may be annoying to some and may also diminish public confidence in the safety and security of air travel. Ground based interceptors are another option that has been suggested. These interceptors could be vehicle-mounted SAMs like the Marine Corps "HUMRAAM" system, or even directed energy weapons like the Army's tactical high-energy laser (THEL). Cost,

¹⁸ Marvin B. Shaffer. *OpCit.*

reliability, probability of intercept, and like dispensing flares, potential side-effects and unintended consequences would have to be weighed when considering these options. Older "lamp-based" IR countermeasures might also offer some missile jamming capability, by generating wide, if relatively weak, fields of IR energy near airports. Again, potential side-effects and unintended consequences would have to be assessed.

Another way to mitigate the threat of shoulder fired SAMs is through intelligence and law enforcement efforts to prevent terrorists from acquiring these weapons, particularly terrorists operating inside the United States. Congress may consider ways to improve current missile non-proliferation efforts, and may also wish to debate ways to better share intelligence information with airport security managers so that appropriate security measures can be implemented to respond to specific threat information.

Conclusion

Because no single solution is likely to immediately and completely mitigate the shoulder fired SAM threat, Congress may consider implementing various combinations of available mitigation alternatives in whole or in part. In addition, Congress may consider phasing in mitigation options to best respond to available threat assessments or other criteria. For example, if threat assessments indicate that large widebody airplanes are most at risk, Congress may consider whether initially equipping these airplanes would more effectively deter the threat of missile attacks. Congress may also consider whether it would be more effective to initially equip aircraft used on overseas flights, particularly those operating in countries or regions where the risk of missile attacks is greatest. Congress may also debate whether equipping only a portion of the air carrier fleet would be a sufficient deterrent, whether all-cargo jets should be equipped, whether passenger carrying regional jets should be equipped, or whether equipping the entire air carrier fleet is needed to adequately mitigate the threat.

Equipping aircraft with missile countermeasure systems has advantages. Countermeasures are fixed to the aircraft, require little or no flight crew intervention, and can protect the aircraft even when operating in areas where ground-based security measures are unavailable or infeasible to implement. Down sides include a high cost, and potentially undermining passenger confidence in the safety and security of air travel. Also, because implementation will take time, countermeasures cannot immediately mitigate today's terrorist threat. Procedural improvements such as flight crew training, changes to air traffic management, and improved security near airports may be less costly than countermeasures and could more immediately help deter domestic terrorist attacks. However, these techniques by themselves cannot completely mitigate the risk of domestic attacks and would not protect U.S. airliners flying to and from foreign airports.